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SOCIOECONOMIC DEVELOPMENT, MEDICAL CARE AND NUTRITION AS DETERMINANTS OF INFANT MORTALITY IN LESS DEVELOPED COUNTRIES

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Introduction

An understanding of the determinants of infant mortality is of critical importance to underdeveloped countries. Quite apart from the urgent need to reduce the enormous human sufferings implied by high infant mortality, such an understanding might facilitate a reduction in fertility, since it is widely accepted that a fall in infant mortality will lead ultimately to lower fertility(Flegg 1982, Preston 1978). However, according to Simmons et al(1982) the inverse phenomenon also important i.e mortality also may be affected by the prior fertility and family size desires of parents, therefore, mortality as a function of fertility also seems to be important.

Demographers and public health personnel disagree as to the determinants of mortality in less developed countries(LDC). McKeown, Brown and Record(1962,1965) demonstrate that the decline in mortality in England and Wales during the eighteenth and nineteenth centuries was largely due to a rising standard of living and cannot be attributed to medical advances. According to Thomlinson (1965) medical improvements, especially the development of asepsis and antisepsis, were responsible for mortality decline in late nineteenth century. Demographers such as Preston(1975) believe that mortality has become increasingly disassociated from economic level because of the diffusion of medical and health technologies, facilities and personnel

that occured in large part, independently of economic level. Davis(1956) talks of the amazing decline of mortality in non-western societies without their undergoing thorough transformation of social and economic structures. Ceylon, the case cited by him, was later examined by Frederiksen(1960) who minimized the contibution of the malaria control campaign in the reduction of mortality. Frederiksen claimed that economic development, by increasing per capita food consumption, was an important cause of the mortality decline in Ceylon. Stolnitz(1955) in an analysis of international mortality trends argued that increase in life expectancy are almost always explained by reference to two broad categories of causes: rising levels of living on the onehand(income,nutrition,housing,literacy); and on the other hand technological advances(medical science, public health,sanitation). He further emphasized that the introduction of new disease-control techniques in Latin America, Africa and Asia had led to drastic mortality declines in the last few years. Rodgers(1979) in his recent international cross-sectional analysis of mortality has noted the following points. The determinants of mortality change in LDC's are not easy to unravel. Improvements in health technology and availabilities are evidently relevant; education plays an important part; sanitation, clean water supply and a host of other environmental variables have undoubted effects. But empirically, the effects of these different factors are diffcult to identify. The variables

tend to be collinear with each other, and with many other aspects of development, making their isolation difficult. Moreover, there is a tendency for health programmes to be most intensive in the least healthy places, for obvious reasons, further confusing observed relationships. For instance, the presence of health programmes often correlates positively with high mmortality.

Studies of the determinants of infant mortality rates(IMR) in LDC's are inadequate in two ways as well:they have not included a sufficient number of explanatory variables;and a satisfactory statistical analysis has not been done. In the present study, an attempt has been made to identify the important determinants of IMR in LDC's through maximum likelihood methods. This method permits greater understanding of the causal connections among the exogenous and endogenous variables and allows a certain amount of measuerment error to remain in the model.

Theoretical framework

Research in different parts of the world has shown the influence of economic development,level of literacy,female labour force participation, health services,nutrition on IMR.

Economic development

The negative relationship between the IMR and the level of economic development has generally been quite strong,

historically as well as cross sectionally and the IMR has often been considered a reliable barometer of the economic deevelopment(UN:1982). Such a relationship has been observed among the developed countries in the mid of 1970's (USA, Canada,Sweden).As the GNP increases the living standard improves along with the improvement in the health services and nutrition(Gaise 1975;Berg 1973). Similar observation has been made by other studies conducted in developing countries(Krishnan 1975: Rodgers 1979) Preston(1975) notes that one would not expect a direct relation between mortality and income per head to exist, because national income is simply a measure of the rate of production of new goods and services. However, income is likely to influence the level of mortality indirectly, through its effects on the rate of consumption of items affecting health, such as food, housing, sanitation,medical care and education. In his international summary on structure and change in causes of death (Preston 1974) observes that certain diseases are thought to be dependent largely upon the standard of living and hence not readily amenable to reduction through specific medical and public health measures(e.g diarrhoeal diseases, which are influenced strongly by nutrition and personal sanitation).

Literacy

Level of literacy is another important index of social advancement which seems to be associated with the level of

IMR. This is especially true among women in the reproductive ages. Because the mother is the immediate agent through whom societal institutions must act to safeguard the health and the life of the child in the home, her attitudes and abilities are of great importance. The literate mother can be assumed to have at least the minimum educational requirements which enable her to take advantage of the scientific child care which the community has to offer. The effect of literacy on IMR tends to be negative and indirect and operates through standard of living , medical and health services and possibily other variables as well(Chang et.al 1979; Chang and Pendelton 1978). Caldwell(1979) on the basis of a rigorous analysis of Nigerian survey data, concluded that maternal education was the most important single determinant of mortality in childhood. Caldwell suggests three main reasons for his findings. First, educated mothers may be expected to break with tradition or become less "fatalistic" about illness and adopt many of the alternatives in child care and therapeutics that become available in the rapidly changing society. Second, an educated mother is more capable than an illiterate one of demanding the attention of doctors and nurses. Furthermore, her knowledge of the available medical facilities is likely to be superior and she will tend to regard their use as a right and not a boon. The final and most important factor is that the education of women greatly changes the traditional balance of familial relationships

with profound effects on child care.

Flegg's (1982) study on the determinants of IMR in LDC's also confirms Caldwell's hypothesis by using female illiteracy as the measure of education. Krishnan(1975) in his case study of India, observed literacy to play two roles. On the preventive side, literacy helps to alleviate mortality by promoting social hygiene and on the control side, the awareness generated is capitalized in making the best use of medical facilities provided by the health program. However, according to Frenzen and Hogan(1982) based on their case of study of rural Thailand have shown that the maternal education does not increase the ability to provide adequate infant care at least to the degree necessary to significantly reduce infant mortality independently of the other social variables, including the health information provided by contact with a doctor, nurse or midwife.

Female labour force participation

In countries, where the status of women is low, increased female labour force participation has considerable influence on IMR. Female labour force participation in the non-agricultural sector has greater influence over the IMR than in the agricultural sector(UN 1982,p 89). Women in the non agricultural sector have very little time to devote to the bearing and rearing of children. Women in this sector also have greater exposure to available medical and health

facilities and tend to take better care of their fewer children. Thus one would expect female labour force participation to have negative influence on the IMR.

Health facilities

The level of IMR has quite often been used to assess the success of the government sponsored public health programmes in both developed and under developed nations. In countries where the majority of the population lives below the poverty line, the government should take effort to provide free medical and health facilities if the poor are to get. Therfore, availability of such facilities to the public is more important in bringing down the level of IMR (UN 1982). Studies by Flegg(1982) and Yang and Pendelton (1980) found the health facilities to play greator role in bringing down the level of IMR in LDC's.

Nutrition

It is well known that balanced nutrition is a necessary condition for human health and survival. Poor nutrition particularly increases the individual's susceptibility to disease.A Wide disparity in food supply has been observed both between developed and developing countries and within developing countries. While the developed countries suffer due to excessive intake of certain foods, the developing countries suffer due to poor nutrition. Children and pregnant or lactating women are particularly vulnerable to

dangers of inadequate food supply. WHO studies indicate that weight gain during pregnancy is lower in poorly nourished population groups. When the dietary condition of the mother is inadequate this tends to be reflected in lower birth weight of newly-born children. Lower birth weights(less than 2500gms) is highly associated with the increased risk of IMR(WHO 1974). Diet and nutrition has been found to play an intervening role between education and mortality(c.f Bengoa 1974; Friedlander and Silver 1967). Yang and Pendelton(1980) observed a positive effect of diet on crude death rate in their recent analysis among the LDC's. This unusual finding may be a mere statistical artifact which requires further investigation.

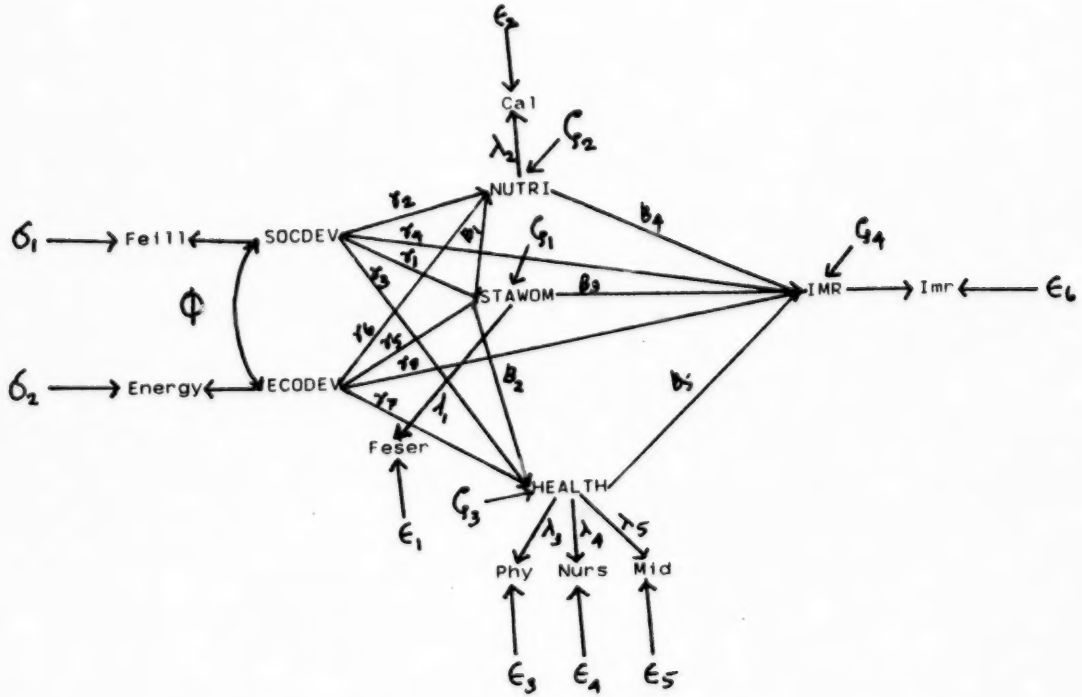
Based on the above review of literature the following concepts have been selected for use in the analysis. Under each concept certain indicators have been selected, again on the basis of their prior successful use in other studies.

1. Economic development(ECODEV)
   a. per capita energy consumption(Energy)
2. Social development(SOCDEV)
   a. percentage of women aged 15 years and over who are illiterate(Feill).
3. Status of women(STAWOM)
   a. percentage of women, aged 15 years and over who are in service sector(Feser).

4. Health facilities(HEALTH)
   a. number of physicians per 10,000 persons(Phy)
   b. number of nurses per 10,000 persons(Nurs)
   c. number of midwives per 10,000 persons(Mid).
5. Nutrition(NUTRI)
   a. per capita calorie consumption as percentage of requirement(Cal)

The rationale for including midwives as an indicator of health concept is that the infant mortality, declines that have occured in LDC's especially in Thailand, during the past few decades have been attributed to both general socioeconomic development and special government programmes to train midwives and provide maternal and child health services in remote areas(Economic and Social Commission for Asia and the Pacific,1976).Percentage of illiterate women has been used as a measure of education (Flegg 1982) in the absence of any other appropriate variable. The unequal distribution of health personnel and unequal access to such personnel by rich and poor families can be better examined by the inclusion of Gini Index of inequality as an explanatory variable (Flegg 1982). In the absence of any such measures for the current observation period is one of the limitations of the study.

Fig 1. Proposed model for showing the determinants of IMR



Data Sources

Data necessary for the present analysis are taken from the sources given in the following.

variable	source
1. Economic development	
Energy consumption	statistical year book(1981)
2. Social development	
Female illiteracy rate	" " "
3. Status of women	
Women 15+in service sector	ILO (1977)
4. Health facilities	
physicians /10,000 persons	Demographic year book(1980)
Nurses /10,000 persons	" " "
Midwives /10,000 persons	" " "
4. Nutrition	
per capita calorie consumption	The world bank(1982)
5. Infant mortality rate	Demographic year book(1980)

Methods

In order test the direct and indirect relationship among the variables the following model(fig 1) was

Table 1. Correlations and covariances for the variables in the model*

	IMR	FESER	CAL	PHY	NURS	MID	ECODEV	FEILL
IMR	1.000	-.608	-.531	-.655	-.520	-.508	-.789	.760
	(.101)	(-.098)	(-.009)	(-.112)	(-.088)	(-.082)	(-.183)	(.103)
FESER		1.000	.421	.715	.571	.384	.690	-.532
		(.277)	(.013)	(.206)	(.160)	(.101)	(.245)	(-.109)
CAL			1.000	.505	.333	.235	.517	-.361
			(.003)	(.016)	(.010)	(.007)	(.023)	(-.008)
PHY				1.000	.637	.455	.804	-.534
				(.292)	(.183)	(.122)	(.320)	(-.188)
NURS					1.000	.422	.570	-.454
					(.285)	(.120)	(.210)	(-.094)
MID						1.000	.370	-.348
						(.274)	(.133)	(-.055)
ECODEV							1.000	-.611
							(.582)	(-.187)
FEILL								1.000
								(.172)

Variances and covariances are in paranthesis.

* correlations and covariances are calculated after transforming the variables by natural logrithm.

proposed. The model was analysed through maximum likelihood methods proposed by Joreskog(1981 version v) because of its obvious advantage over the usual path analysis techniques. The diffculties involved in path anlalysis techniques are explained by Joreskog (1977,p 200). Besides computational convenience, LISREL avoides potential problems with biased estimates by adjusting for measurement error (Entwisle and Hayduk 1981). It also furnishes modification indices and partial derivatives that give some clue about the validity of the model structure. It allows for exploration of reciprocal effects, if any in the model. Above all LISREL allows the use of multiple indicators for the estimation of theoretical variables.

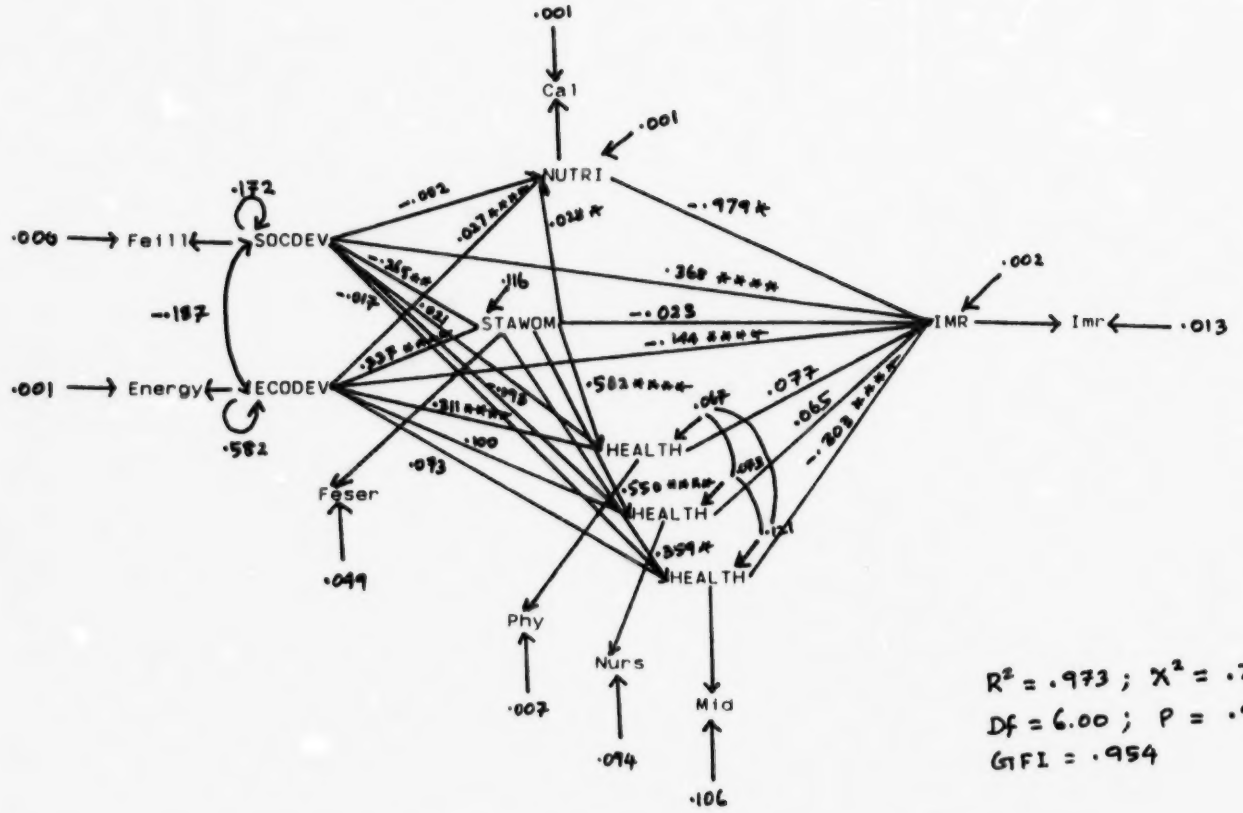
Analysis

In a preliminary analysis the interrelationship between IMR and the independent variables was examined through zero order correlations(table 1). All the variables were correlated significantly in the expected direction. However the rather low correlation of midwives with physicians(.221) and nurses(.195),and the high correlation of economic development with midwives (.618) as opposed to rather than with physicians(.518) and nurses (.414) were not expected. The exploratory data analysis(stem and leaf and schematic plots) indicated skewness and outliers among all the variables.

Therefore variables have been transformed by using natural logrithms. After the transformations the correlations of midwives with physician(.455) and nurses(.422) increased considerably. The magnitude of the correlations of economic development with health variables like physician(.804) nurses(.570) and midwives(.370) were also changed as expected. Countries like HongKong and Singapore were excluded from the analysis due to the fact that their IMR's were below many of the developed countries. Thus the analysis was carried out for only 60 countries based on the availability of data.

The maximum likelihood estimates derived for the proposed model showed the causal linkages among the variables in the expected direction. However, the fit of the model was poor. The goodness of fit index was .66(X^2 = 49.36,df=17,p=0.000) The modification indices and first order derivatives obtained for the model suggested to free the covariances among the measurement errors of health indicators. When the measurement errors were allowed to correlate they were found to be negatively related, which indicates that the errors involved in measuring the health indicators were not in the same direction in various countries. The above modification moreover improved the model considerably. The chi-square dropped from 49.39 to 22.74 for the loss of 3 degrees of freedom(GFI=.76,p=0.065).The influence

Fig 2. Lisrel estimates (metric coefficients) for the final model showing the determinants of IMR.

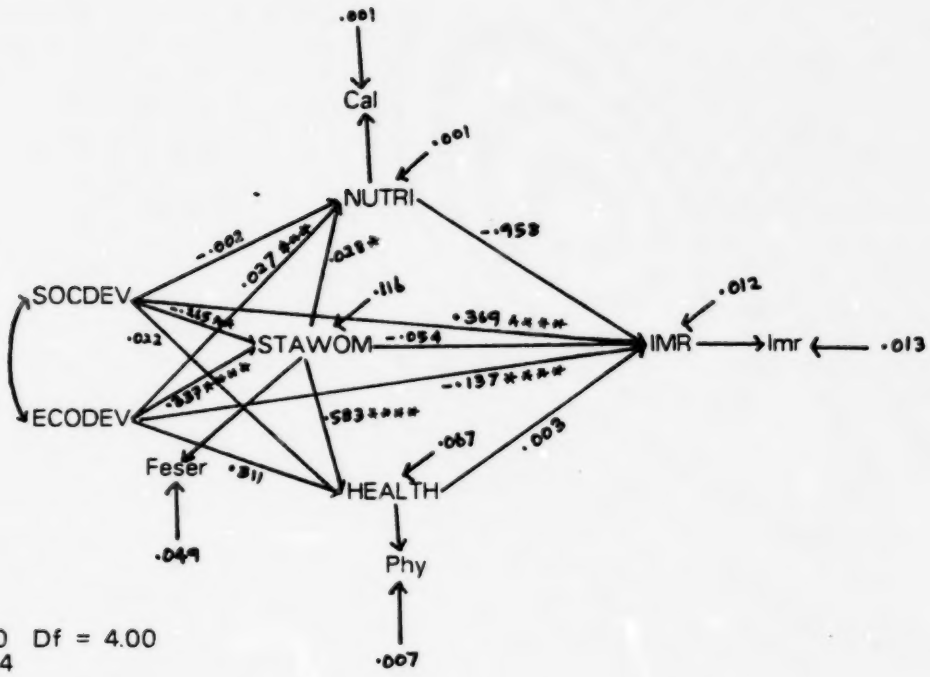


$R^2 = .973$; $X^2 = .79$
Df = 6.00 ; P = .992
GFI = .954

Note: The level of statistical significance of each estimate under the one tailed t test is indicated by ****, ***, ** and * for the one, two, five and ten percent levels respectively.

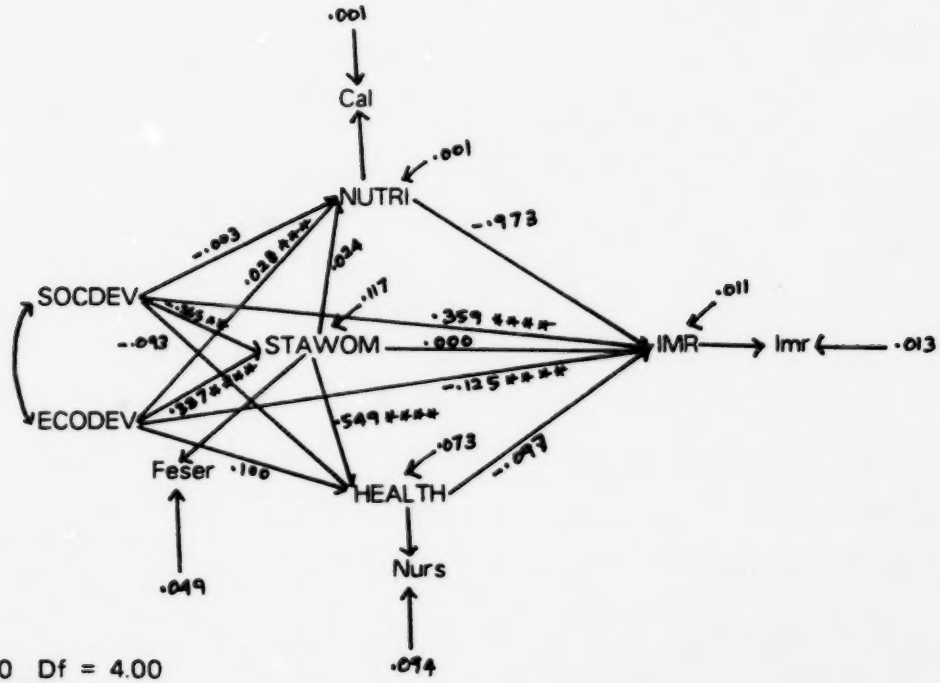
Lisrel estimates (metric coefficients) for the modles 1-3 to show the determinants of IMR for different health indicators.

Fig 3; Model 1



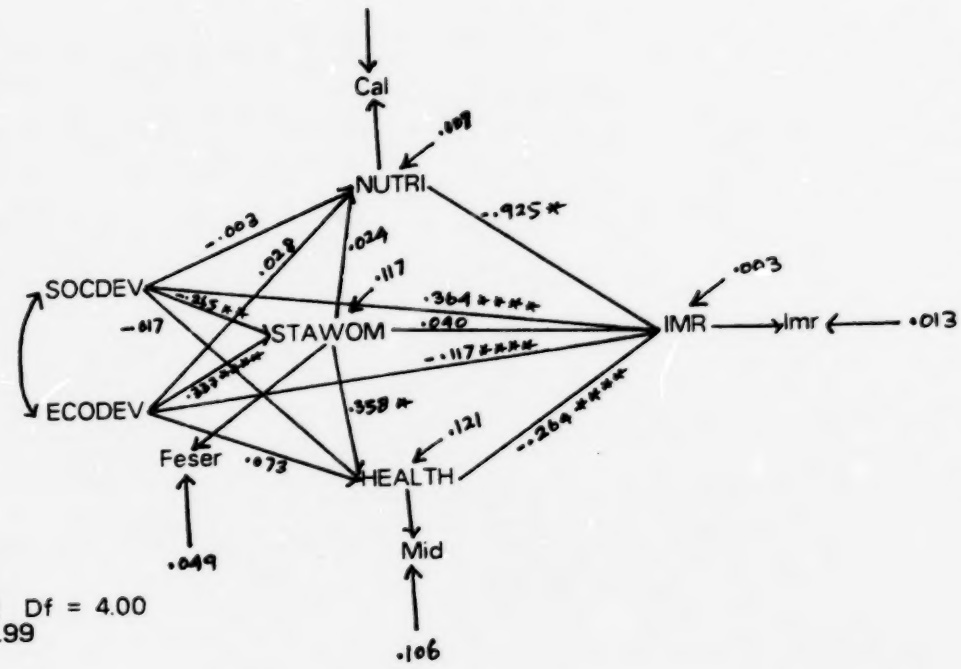
R^2 = .90 χ^2 = .70 Df = 4.00
P = .95 GFI = .94

Fig 4: Model 2



R^2 = .87 χ^2 = .00 Df = 4.00
P = 1.00 GFI = 1.00

Fig 5: Model 3



R^2 = .95 χ^2 = .02 Df = 4.00
P = 1.00 GFI = .99

of the health variable on IMR increased significantly (-.016 to -.107) and the remaining variables were more or less in the same magnitude.

The negative correlations of measurement errors among health indicators led us to treat them as separate concepts rather than including them as indicators of the same concept(Health).

Figure 2 shows the model with three separate health concepts and correlated disturbance terms(PSI).The chi-square of .79 with 6 degrees of freedom (p=.992) indicates the best fit of the model. The goodness of fit index was .954 and the coefficient determinatior was 97 per cent.

Prior to accepting the above model as final, several submodels were attempted by adding taking health indicators one by one to the system. This would help us justify the treatment of health indicators separately rather than as indicator of the same concept (Health). In fact, the influence of each health indicators on IMR in the absence of other indicators can be better determined.

In figure 3 where the number of physicians to population has been used to measure the health concept,the best fit of the model(X^2 =.70,df=4.00,p=0.951,GFI=.944) is shown. While all the

variables had their expected influence on IMR, the health variable had almost no influence on IMR(.003).

The best fit of the model which uses the number of nurses to population as a measure of health (X^2 = 0.000,df=4.00,p=1.000,GFI=1.000) is shown in figure 4. A noticeable changes from the preceding figure is the influence of status of women on IMR.The health variable which showed a negative influence on IMR was again not statistically significant. On the other hand, the status of women had a direct positive and indirect negative influence on IMR (statistically significant). The inclusion of nurses as the indicator of the health concept, slightly reduced the influence of social(.369 to .359)and economic development(-.137 to -.125) on IMR and also its own impact by economic development(.311 to .100) and status of women(.583 to .549).

In figure 5 a best fitting model is shown using midwives to population as indicator of health(X^2 = 0.02,df=4.00,p=1.000,GFI=.994). when midwives are used as a health proxy, the influence of health on IMR increased from -.097 to -.264 and becomes statistically significant. The inclusionof midwives in to the system reduced the influence of nutrition(-.973 to -.925) and economic development(-.125 to -.117) on IMR and increases slightly the slopes of social development(.359 to .364) and status of women(.000 to .040) on IMR.

Table 2: Metric and standardized coefficients of exogenous and endogenous variables for the model in fig 2.

Variables	STAWOM			NUTRI			PHY			HEALTH NURS			MID			SOCDEV			ECODEV		
	D	IN	T	D	IN	T	D	IN	T	D	IN	T	D	IN	T	D	IN	T	D	IN	T
STAWOM																-.265 (-.230)	-	-.265	.337 (.538)	-	.337
NUTRI	.028 (.275)	-	.028													-.002 (-.020)	-.008	-.010	.027 (.428)	.009	.036
HEALTH Phy	.582 (.521)	-	.582													.021 (.017)	-.154	-.133	.311 (.445)	.197	.508
Nurs	.550 (.601)	-	.550													-.093 (-.088)	-.145	-.238	.100 (.174)	.185	.285
Mid	.359 (.408)	-	.359													-.017 (-.017)	-.095	-.112	.073 (.135)	.121	.194
IMR	-.023 (-.038)	-.056	-.079	-.979 (-.158)	-	-.979	.077 (.138)	-	.077	.065 (.096)	-	.065	-.303	-	-.303	.368 (.514)	.024	.392	-.144 (-.369)	-.044	-.188

D = Direct effect; IN = Indirect effect; T = Total effect

Standardized coefficients are in paranthesis.

In sum, the analysis of submodels indicates that the traditional way of considering these health indicators,i.e. that they are assumed to measure the same concept(Health) no longer seem to be appropriate. Especially, when the unit of analysis is "countries" such an assumption would lead to wrong conclusions based on our present findings. Therefore, the following discussion will be based on the model (fig 2) in which the health indicators were treated separately, allowing only for their structural disturbances to be correlated. Since the LISREL program is based on full information maximum likelihood procedures, the estimates obtained are after partialing out the effect of other variables in the system. Such estimates, provide the actual influence of an variables on the same system.

Discussion

For the final model the metric and standardized coefficients are presented in table 2.

As per the model presented in figure 2 socioeconomic development has direct and indirect influence on IMR through status of women,nutrition, and health. The status of women, which is also an indicator of general development in the society, is assumed to influence the IMR directly and also indirectly through health variables. No causal connections between the health variables are included, except the correlations

through their structural disturbance terms.

The exogenous variables

The effects of the two exogenous variables(socio-economic development) on endogenous variables are quite different in magnitude despite their intercorrelation of .611. As shown in table 2 social development does not seem to have a significant direct effect on nutrition(-.002) and health variables like physician(.021) nurses(-.093) and midwives(-.017). On the other hand, the indirect influences of social development on physician(-.154) nurses(-.145) and midwives (-.095) are greater in magnitude while the reverse is true on IMR. In other words, social development tends to influence nutrition and health largely through its indirect impact on status of women prevailing in that society. On the whole, social development has a more strong direct(.368) than indirect(.024)influence on IMR. The standardized coefficients given in table 2 also indicates that social development has strong influence on IMR(.514) and status of women(-.230) and comparatively weaker influence on nutrition (-.020) and health.

.Economic development has a significant direct influence on status of women, the number of physicians and a modest negative relationship with infant mortality (table 2). Standardized coefficients confirm that

economic development has a very strong and significant influence on status of women (.538) followed by number of physicians(.445) nutrition (.428) and IMR(-.369). Economic development has comparatively weaker effect on number of nurses (.174) and midwives(.135). The indirect effects of economic development on nurses (.185) and midwives(.121) are slightly larger than its direct effects.

The endogenous variables

The standardized coefficients(table 2) show that status of women has a strong influence on number of nurses(.601) followed by physicians(.521) midwives(.418) and nutrition((.275). Status of women has a very weak direct influence on IMR (-.038). On the otherhand, nutrition(-.158) and midwives(-.419) among the health variables have significant negative influence on IMR. Physicians and nurses have non-significant positive influences on IMR. One possible explanation for this results could be as Rodgers(1979 p343) noted that health programmes are often most intensive in the least healthy places. Voluntary agencies and various international developmental agencies tend to allocate their staff to the least healthy places in various parts of the world in order to achieve the goal of "health for all" by the year 2000. An interesting contrary finding is that midwives have significant negative influence on IMR.

Table 3: Standardized coefficients for the models in figures 3 to 5.

Variables		STAWOM			NUTRI			HEALTH			SOCDEV			ECODEV		
		M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
STAWOM	M1										-.230			.538		
	M2											-.230			.538	
	M3												-.230			.538
NUTRI	M1	.280									-.019			.428		
	M2		.237									-.029			.448	
	M3			.240									-.028			.446
HEALTH	M1	.521									.017			.445		
	M2		.601									-.088			.174	
	M3			.417									-.017			.136
IMR	M1	-.087			-.155			.005			.515			-.351		
	M2		.000			-.157			-.143			.502			-.322	
	M3			.064			-.150			-.365			.509			-.301

M1 = model using number of Physicians as an indicator of health.
M2 = " " " " Nurses " " " .
M3 = " " " " Midwives " " " .

The analysis of submodels given in figures 3 to 5 and table 3 also supports the above finding. Though the number of nurses had negative influence on IMR(-.143), in the presence of health variables its influence became positive (.096). The number of midwives, on the other hand, showed significant negative effects both in the presence(-.303)and in the absence (-.365) of other health variables. Further discussion of the above finding is necessary.

In general, discussion of the availability of health personnel restrict themselves to the number of physicians and number of nurses. The role played by staff at the grass roots level i.e. community health volunteers or 'bare foot doctors'(in China), multipurpose workers and auxillary nurse midwives are seldom taken into account. It has been assumed that the availability of all kinds of health personnel has the same effect on IMR. This is apparantly not true. Moreover, this finding is important because in countries, where the level of literacy is low, where awareness and accesibility to health facilities are also low, health care should be delivered to the door of the poor sector. Otherwise the existence of such facilities may not be very useful. Workers at the grass roots level can be special benefit in effecting the delivery of such public health services. Midwives, are an example of such grass roots workers and are involved in

the community to a great extent in some societies. This enables them to provide the preventive and promotive health care services more effectively than formal health care personnel. Essential prenatal and postnatal care are often deliverd by midwives. On the other hand, nurses often merely do the doctor's dirty work and have little authority on their own. They could perform some tasks without a doctor's supervision but they are not allowed to do this. If they were, it would improve the functioning of the system where it is least efficient(Perry 1978, p335). A survey (Jayachandran et al, 1980) conducted in India in order to evaluate the reach of Primary Health Care in that country came to the following conclusions. "Family planning got a much higher priority in comparision with other work. Preventive and promotive aspects which should normally be given high priority among the PHC(Primary Health Centre) responsibilities, were grossly neglected. The medical officers were mainly interested in clinical work and meeting the target requirement as asked by the district office. The lowest level of staff viz; multipurpose workers and the auxillary nurse midwives worked in conditions which were less than satisfactory. Medicine supplies and other equipments were either not there or were non functional". Even in the field of family planning studies conducted in different parts of the world have shown that the non physicians were

Table 4. Disturbance term variances, covariances, correlations and degree of determinac) for the model in fig 2.

Variable	STAWOM	NUTRI	PHY	NURS	MID	IMR	R
STAWOM	.116	.575	.812	.766	.518	-.691	.489
NUTRI		.001	.570	.491	.332	-.642	.434
PHY			.067	.786	.556	-.704	.764
NURS			.027	.073	.671	-.684	.616
MID			.022	.046	.121	-.675	.280
IMR						.002	.974

Correlations given above the diagonal of each matrix are calculated from the standardized solution.

generally found to be as competent as doctors in the provisons IUD's(Eren et al 1983). The study conducted by Eren et.al(1983) further justifies that adequately trained auxillary nurse-midwives can provide standards of clinical care for IUD users comparable to those provided by physicians. It also suggests that nurse-midwives may provide a more effective service because they are more acceptable and accessible to clients. Further readings on the comparisions of auxillary nurse midwives and physicians in providing family planning service can be obtained from Eren et.al(1983). Therefore, the urgent need in LDC's may not be for highly sophisticated physicians but rather for workers at the grass roots level who are closer to the community. such a step is further important in countries where the level of literacy is low, and the availability and accessability of the health facilities is limited only to certain sectors of the population. Merely to increase the number of physicians or nurses might not play as vital a role in the reduction of the IMR in LDC's as the use of trainning funds to produce more midwives and other workers at the village level.

The amount of variance explained(R^2),disturbance terms(PSI) and expected correlations are given in table 4. The total amount of variance explained by all the variables in IMR is 97 per cent.

Conclusion

Our findings strongly suggest that the level of socio-economic development plays a significant role in bringing down the level of the IMR. They also suggest that such a development should be coupled with the improvements in health personnel and nutrition. The need for workers at the grass roots level in the over all health care delivery system should be recognized. Health care delivery should shift from hopital-based, disease treatment oriented ("basic health care") to "primary health care" which emphasizes prevention through improvements in education, nutrition, water supply and sanitation.

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